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COMPARISON BETWEEN ULTRA SOUND (US) AND MACRODISECTION MEASUREMENTS OF HUMAN FOETAL KIDNEY

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A b s t r a c t : Development of the foetal human kidney runs through a series of continual and mutually dependent changes during which the kidney obtains its morphological and functional maturity.

In recent times, there has been a significant improvement in intrauterine observations of the normal growth and development of the foetus, as well as of anomalies in the development of foetal organs. Ultrasound measurement of foetal kidney dimensions provides monitoring of the normal growth and development since the anomalies in the growth are most strikingly expressed in changes in the kidney dimensions.

Kidney size in relation to gestational age was determined by 60 Ultra Sound photos of 60 intrauteral foetuses of both sexes and macrodisectional measurements of 60 foetuses *post mortem* with gestational ages from 18 to 31 weeks. The renal volume was calculated from the outer kidney diameters using the volume formula for an ellipsoid. The results were statistically analyzed. Student's t-test and Mann-Whithney U Test were applied.

The examinations have shown that the kidney is an organ that undergoes complicated changes during embryonic development. Therefore, knowledge of these measurements may contibute to earlier diagnosis of a variety of abnormalites.

Key words: foetal kidney, kidney dimensions, kidney volume.

Introduction

Interest in the foetus's life used to be focused, for centuries, on the studies of the embryo and mechanical problems encountered by the gynecologist at

the delivery. Nowadays, it is well known that the development of the foetus is not proportional to the growth of its organs, and each stage in foetus's life is specific.

The development of the kidney is a complex process and has three phases: primary kidney (pronephros), middle or secondary kidney (mesonephros), and definitive kidney (metanephros). The kidney is a parenchymal organ and it is always examined as a morphological and functional entity. Kidney variations during foetal growth, as well as individual variations of different segments of its structure, are permanent and persist after birth. Their recognition and mode of onset would be a significant contribution to the current surgical treatment of these changes. The aim of this research is to review a comparison between Ultra Sound (US) and Anatomic examinations of human foetal kidney growth and development.

Material and methods

The material for investigation of foetal human kidney was obtained from the Gynaecology and Obstetrics Clinic, Clinical Centre, Skopje. Ultra Sound measurements were performed in 60 Ultra Sound photos of intrauteral foetuses, and on 60 foetuses *post mortem*. All the foetuses were of normal pregnancies with a gestational age from 18 to 31 weeks. Foetuses with malformations or other serious disease were excluded from the study. Gestational age was based on the last menstrual cycle. Gestational age as per mother's last period was calculated using Negel's formula: 7 days are added and 3 months are subtracted from the first day of the last menstruation. Macrodissection was used on 60 extracted kidneys *en bloc*, which were carefully separated from the surrounding tissue. Afterwards, length, width and thickness were measured by a Vernier caliper gauge. The length is the distance between the most remote points of the two poles, and the width and thickness were measured at the level of the hilus.

Renal volume was calculated from the outer kidney diameters using the elipsoid formula:

$$\text{Volume} = \text{length} \times \text{width} \times \text{thickness} \times \pi/6.$$

All parameters were statistically processed and are graphically shown. Student's t-test and Mann-Whithney U Test were applied.

Results

The study included a sample of 60 Ultra Sound photos and kidneys of 60 foetuses *post mortem* of both sexes with gestational ages from 18 to 31 weeks.

Table 1, Figure 1 shows the values of the central tendency (average values, exceptions to the average values, minimal and maximal values) of the estimated parameters of both kidneys – length, width, APD and V measured anatomically.

Table 1 – Табела 1

Macrodissection measurements
Макродисекциони мерења

	Left kidney					Right kidney				
	N	Mean	Min.	Max.	Std. Dev.	N	Mean	Min.	Max	Std. Dev.
Length	60	2.036	1.00	3.00	0.64	60	2.08	1.00	3.10	0.65
Width	60	1.018	0.50	1.50	3.22	60	1.048	0.50	1.60	0.32
APD	60	0.481	0.20	0.70	0.16	60	0.506	0.20	0.80	0.16
V	60	0.68	0.05	1.64	0.53	60	0.77	0.05	2.07	0.58

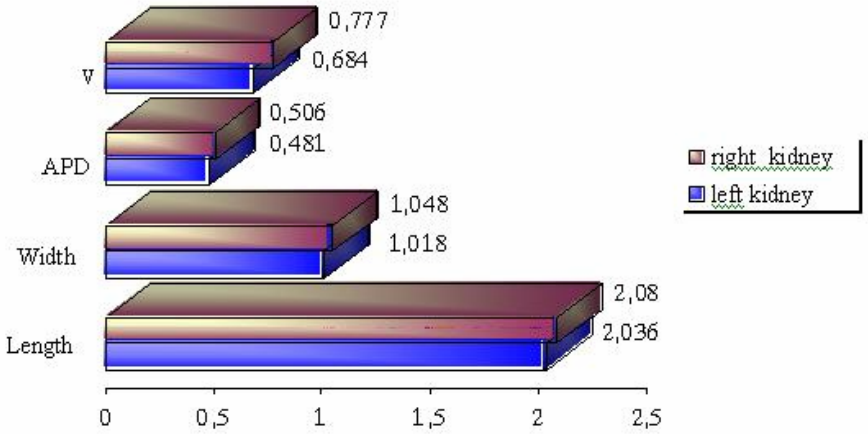

Figure 1 – Macrodissection measurements
Слика 1 – Макродисекциони мерења

Measurements of the central tendency of echotomographic estimated size of both kidneys are presented in Table 2, Figure 2

Table 2 – Табела 2

US measurements
Ултразвучни мерења

	Left kidney					Right kidney				
	N	Mean	Min.	Max.	Std. Dev	N	Mean	Min.	Max	Std. Dev
Length	60	2.036	1.00	3.10	0.64	60	2.055	1.00	3.10	0.66
Width	60	1.038	0.50	2.10	0.34	60	1.045	0.50	1.60	0.32
APD	60	0.486	0.20	0.80	1.66	60	0.506	0.20	0.80	0.16
V	60	0.693	0.05	2.07	0.55	60	0.790	0.05	2.07	0.60

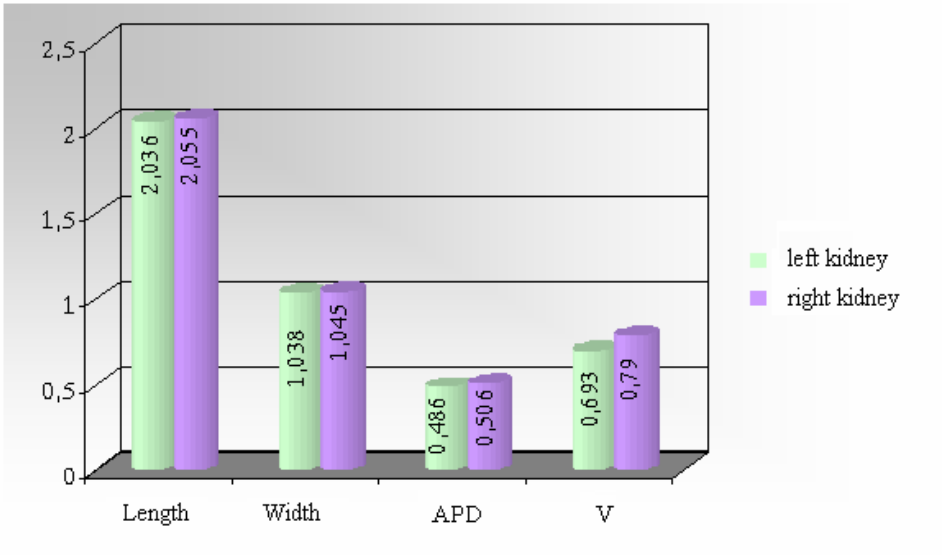

Figure 2 – US measurments
Слика 2 – Ултразвучни мерења

Tested results of the echotomographic and anatomic measured values for the length, width, APD and V of the both the right and the left kidney are demonstrated in Table 3. From the results obtained from the tests used (t-test of independent examples and Mann-Uitney U-test as well as p value), it can be stated that the differences are statistically insignificant, i.e. the parameters of both kidneys analyzed anatomically and echotomographically have the same values or the values have slight differences.

Table 3 – Табела 3

Differences
Разлики

	t-test for independent samples				
	Mean Group 1	Mean Group 2	t-value	p	Sig. / N. sig.
Left kidney / length	2.036	2.036	0.00	1.000	N. Sig.
Right kidney / length	2.080	2.055	0.207	0.84	N. Sig.
Left kidney / width	1.018	1.038	-0.32	0.74	N. Sig.
Right kidney / width	1.048	1.045	0.056	0.96	N. Sig.
Left kidney / APD	0.482	0.487	-0.164	0.87	N. Sig.
Right kidney / APD	0.507	0.507	0.00	1.00	N. Sig.
Left kidney / V	0.68	0.69	-0.093	0.92	N. Sig.
Right kidney / V	0.78	0.79	-0.11	0.91	N. Sig.

Discussion

Greater congenital anomalies of the kidney, for example, infantile polycystic kidney disease, bilateral agenesis or foetal hydronephorosis, could be found by prenatal US measuring of the kidney dimensions – Kurjak and Zmijanac [1]. For this reason it is necessary to establish the normal foetal kidney size precisely. A simple ultrasonographic method, i.e., measurement of the kidney length, can detect a renal abnormality as early as at 14 gestational weeks – Zalel *et al*. [2].

Measuring the foetal kidney size can also help in determining the gestational age, especially in cases where the date of the mother's last period is unknown, and routine methods show contradictory results – Konje *et al*. [3]. Vlajkovic S, Vasovic L, Dakovic-Bjelakovic M [4] used material from 110 foetuses which had no obvious structural abnormalities. All the foetuses were part of the collection of the Anatomy Department, Niš Clinical Centre, Niš. This study was created to estimate the changes in kidney size during gestation in foetuses from the 4^{th} and the 10^{th} lunar months and to evaluate the dynamics of their growth, as well as to establish the validity of the volume calculated from renal length, width and thickness. Gupta AK, Anand NK, Lamba IM [5] measured length, width and anteroposterior diameter within 48 after birth in 100 healthy neonates within gestational ages from 26.14 to 41.28 weeks and birth weights from 540

to 3250 g. On a linear regression analysis, a highly significant correlation was found between renal dimensions and gestational age. Many authors have measured the volume of foetal or adult kidneys by using US or magnetic resonance images (MRI) and then the ellipsoid formula was applied to the values obtained by these methods. Using this technique, the kidney volume ('theoretical kidney volume') is calculated by measuring the three axes of the kidney thinking that it resembles an ellipsoid – Hsieh *et al*. [6], Silver *et al*. [7]. Chiara A, Chirico G, Barbarini M, *et al*. [8] measured kidney volume in relation to gestational age. Birthweight and height were determined in 121 infants, 58 female and 63 male, with gestational ages from 23 to 43 weeks (mean 33.3) and birth weight from 430 to 4600 g. (mean 1982 g). Mean volume of the right kidney in the infants studied was 6.6 ml (range 1.5 to 15.6 ml) with no significant difference. A highly significant correlation was found between the volume of both kidneys and gestational age. Sureyya *et al*. [9] have found statistical difference in size between preterm and term babies. The study of Konus *et al*. [10], which included 307 children, found a good correlation between height and organ dimensions. Dinkell *et al*. [11] reported a good correlation between kidney size and body weight in childhood.

In our study, there was no significant difference in kidney dimensions between male and female foetuses ($p > 0.05$).

Conclusion

The importance of this study is in determining the average values of foetal kidney dimensions, which could be used as standard values in obstetrics.

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Р е з и м е

КОМПАРАЦИЈА ПОМЕЃУ УЛТРАЗВУЧНИ И МАКРОДИСЕКЦИОНИ МЕРЕЊА НА ЧОВЕЧКИОТ ФЕТАЛЕН БУБРЕГ

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Развојот на човечкиот фетален бубрег минува низ серија од континуирани и меѓусебно зависни промени при што бубрегот ја задржува морфолошката и функционална зрелост.

Од неодамна се појавил значаен напредок во интраутерините испитувања на нормалниот развој и развиток на фетусот но и на аномалиите во развојот на феталните органи. Ултразвучните мерења на феталниот бубрег со неговите димензии обезбедува набљудување на нормалниот развој и раст откако аномалиите во развојот се најпечатливо изразени во промената на димензиите на бубрегот.

Големината на бубрегот во релација со гестациската возраст беше утврдена од 60 ултразвучни фотографии на интраутерини фетуси и 60 фетуси post mortem од двата пола од 18 до 31 недела. Бубрежниот волумен беше пресметан од надворешниот бубрежен дијаметар, користејќи ја формулата за елипсоида. Резултатите се статистички анализирани. Користени се Студентовиот t-test и Mann-whithney U Test.

Испитувањата покажаа дека бубрегот е орган кој подлежи на сложени промени за време на ембрионалниот развој. Поради тоа, знаењето од овие мерења може да придонесат во раната дијагноза на бројните аномалии.

Клучни зборови: фетален бубрег, фетални димензии, фетален волумен.

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